Report of the Combined

Director's Review Committee

Director's Review

of CDF and D0

Run IIb Detector Upgrades

August 12-15, 2002

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Report on Director's Review of Run IIb Upgrades

Executive Summary

TECHNICAL

Both experiments have made outstanding progress in moving toward the baseline review. Designs are clearly mature and all major aspects of the upgrades are supported by in-depth studies. The experimenters are to be congratulated for their efforts. We expect that this work will lead to an efficient and smooth upgrade process. We believe both experiments are very close to being ready for their baseline review.

It is recommended that both experiments use the same baseline luminosity conditions for Run IIb. Based on recent developments these appear to be 2×10^{32} /cm^2/sec with 396 ns bunch spacing for normal operation, and 4×10^{32} /cm^2/sec with 396 ns bunch spacing to demonstrate adequate headroom. These figures have been used in some cases but not all.

In many cases the performance of trigger systems at higher luminosities is estimated by linear extrapolation from lower rate conditions. More realistic simulations involving multiple events per bunch crossing should be done.

The plan for upgrading commercial processors during Run IIa, in preparation for Run IIb is rather different for the two experiments and is coupled to operating expenses for the two experiments. The difference in the upgrade plans should be justified or the plans reconsidered.

Some aspects of the TDRs would benefit from further attention. For CDF it would help to strengthen or expand the technical descriptions for the Central Preradiator, the Level-2 decision crate, and installation planning. For D0 there is no discussion of installation planning. There is also no overall table of contents.

COST

In addition to the cost considerations and comments by the technical subcommittee, about 1 and 1/3 additional days were spent examining the cost estimates by the cost schedule subcommittees. Both experiments have tried to document their estimates at the lowest level. D0 has done so considerably more thoroughly than CDF. CDF should put additional effort into assembling this documentation in preparation for the Lehman Review. The more complete D0 basis of estimate (BOE) could benefit from additional organization and labeling. The non-silicon D0 estimates plus contingency seem adequate. The adequacy of the CDF non-silicon estimates cannot be judged due to incompleteness of the BOE.

The Silicon subprojects of both projects are well developed. These Silicon subprojects comprise by far the largest fraction of the costs at approximately two thirds of the total project cost. BOEs for these subprojects are well flushed out for D0 and better for CDF than for the non-silicon CDF systems. The cost for the D0 Silicon is $20,294K compared to $18,138K for CDF. Three fourths of the difference is due to different labor estimates.

Total labor requirements were developed by each project for Silicon and a comparison was made as a joint effort. The D0 labor is markedly larger than that of CDF, averaging ~70 FTEs versus ~40 FTEs. Neither project presented actual labor costs from prior silicon detector construction experiences. Absent such data, comparisons of the ratio of labor costs to M&S costs for two "factory-like" efforts (one recently completed the other currently underway and about 2/3 complete) on HEP detector components here at Fermilab were made. Based on these comparisons, the committee believes the D0 labor hours are likely more reflective of what will actually be needed.

SCHEDULE

The schedule management approach of having an aggressive Project Manager's schedule with more realistic Director's Milestones is endorsed. Meeting the Directors Milestones will not be easy. However, we believe they can be met if the following conditions are met: adequate project management and administration staff and support exists, level 3 managers are put in place and level 2 and level 3 managers dedicate adequate time (frequently full time) to their tasks, adequate engineering and technical support staff (including contingency labor) to carry out the work is provided, laboratory management provides a high level of support and puts a high priority on these projects, and Project Managers effectively manage the overall effort.

MANAGEMENT

D0 has staffed to a deeper level than CDF. Both projects need to add staff and complete many MOU's with collaborating institutions. Both projects have contributed to the Acquisition Execution Plan that is well along. A draft Project Execution Plan has been prepared and draft Project Management Plans exist. These drafts should be made final or near final by the time of the Lehman Review. Additional important management comments are made in the Schedule section above.

Introduction

A Director's Review of the CDF (Collider Detector Facility) and D0 Detector Upgrade Projects was held August 12 – 15, 2002. This technical, cost, schedule, and management review was held in preparation for an anticipated DOE Review (Lehman Review) that it is hoped will recommend the projects be baselined.

These projects were reviewed in December, 2001 by a Technical Review Committee (TRC) selected by the Director. There was also a Director's Review of the projects in April 2002. This Director's Review committee included the TRC members as a Technical Subcommittee.

A charge for the review, an agenda, and lists of committee members, participants and attendees are all included as appendices to this report.

The agenda was structured in a manner that some of the technical consultants with tight time constraints could leave on the afternoon of the third day of the review. As can be seen in the agenda it had been planned to split into parallel sessions on the afternoon of the second day. However, the direction of questions and concerns were such that they did not split into separate technical and cost/schedule/management categories. So, we continued to meet as a committee of the whole through the entire second day.

The report is written in two sections: 1) Technical Report and 2) Cost, Schedule and Management Report. The report structure enumerates findings, comments, and recommendations for clear and easy future reference.

1. Technical Subcommittee Report

Both experiments have made outstanding progress in moving toward the baseline review. Designs are clearly mature and all major aspects of the upgrades are supported by in-depth studies. The experimenters are to be congratulated for their efforts. We expect that this work will lead to an efficient and smooth upgrade process. We believe both experiments are very close to being ready for their baseline review.

1.1. The CDF and D0 Silicon Projects

1.1.1. Introduction

1.1.1.1. Both the CDF and D0 groups have submitted updated TDRs for the complete replacement of their silicon detectors. The maturity of the designs has increased greatly, and the scope of the proposed upgrades has not changed since the last review.

1.1.1.2. The CDF proposal is described in detail in 64 pages of TDR and supplemented with 600 lines of detailed schedule and 145 pages of WBS dictionary. The total project cost is about $18.2 M including escalation, contingency and overhead.

1.1.1.3. The D0 proposal is described in detail in 170 pages of TDR and supplemented with 1200 lines of detailed schedule and 280 pages of WBS dictionary. The total project cost is about $ 22.9 M including escalation, contingency and overhead.

1.1.1.4. The proponents should be congratulated on their successful efforts in preparing the reports and presentations. The committee also commends the cooperation between the two experiments on various technical issues.

1.1.2. Silicon sensors

1.1.2.1. Findings:

1.1.2.1.1. Both collaborations have selected high quality silicon sensors mainly from the same source.

1.1.2.1.2. D0 is considering the option of acquiring the sensors for layers 0 and 1 from another source and will make a decision based on performance after irradiations.

1.1.2.2. Comments:

1.1.2.2.1. The sensor’s simple design and the fact that they are single-sided have lowered the risk greatly.

1.1.2.2.2. Layer 0 and 1 sensors performance dominate the impact parameter resolution and their quality is therefore crucial for overall performance.

1.1.2.3. Recommendations:

1.1.2.3.1. When deciding on the vendor for the silicon detectors of the inner layers, D0 should consider the increased risk of buying from a low-volume vendor. Other factors to be considered include production yield, strip yield, and production stability, in addition to radiation performance.

1.1.3. Electronics and cables

1.1.3.1. Findings:

1.1.3.1.1. The SVX4 prototype chip has been received and tested, and it works very well. The experiments plan to fix some minor problems before production.

1.1.3.1.2. D0 has shown noise and pedestal results of a layer 1 module equipped with SVX4 chips and connected to ELMA detectors. This represents a major success on many fronts. CDF has also positively characterized the SVX4 chip mounted on a hybrid prototype, in addition to a full stave equipped with SVX3d chips. A full stave prototype with final components is being prepared.

1.1.3.1.3. Both D0 and CDF have made good progress on the analog cables for layer 0. In particular, CDF continues to develop a 50 μm pitch analog cable, while D0 now takes a conservative approach using 100 μm pitch stacked cable. The D0 approach greatly reduces the technical difficulties. D0 has already received two batches of prototypes with good yield. In addition, they have assembled a full layer 0 module and have studied the noise pick up problem. They have reproduced the present CDF layer 00 noise problem and found an effective grounding scheme to solve it.

1.1.3.1.4. Both experiments have experienced unexpected failures in some parts of their current detectors and have now tried to mitigate the effects of failure modes in their designs. This is particularly true in the wake of the CDF radiation accident of last March. This accident has been studied in detail, but the underlying mechanism is still not understood. As a partial countermeasure CDF has introduced a Priority Bypass Chip that would limit the effect of such a failure to a single hybrid instead a full readout chain.

1.1.3.2. Comments:

1.1.3.2.1. The success of the SVX4 chip is the single most important element of the presentations. It eliminates a major source of concern and puts the groups in the unusual condition of starting the project with an almost final readout IC in hand. The complete characterization of the SVX4 ASIC is very important before the next prototype is submitted. The different noise figures presented should be reconciled. The plan of acquiring from the November 2002 submission a large fraction of the chips ultimately needed, seems to be a good hedge against schedule risk.

1.1.3.2.2. The hybrid development is also on the critical path and great attention has to be paid to it.

1.1.3.2.3. The construction of module and stave final prototypes, with their potential for uncovering problems early in the construction phase, is a crucial step that the groups recognize and are pursuing at full speed.

1.1.3.2.4. The analog cables connecting the layer 0 strips to the hybrids are recognized as a technical risk by both the committee and the groups. The cables involve two major concerns: production yield and noise pick-up. Many experiments have experienced problems with low production yield of fine pitch flex cables, and CDF is experiencing noise pick-up problems with the analog flex cable in their current layer 00 detectors. The robustness of D0’s stacked flex cable still needs to be evaluated, whereas the vendor providing CDF fine pitch cables has been known to have inconsistent quality in production, especially in the ability to wire-bond.

1.1.3.2.5. Although alternative design solutions for layer 0 might be possible, the current design is the one that has been proven for the CDF layer 00. Both groups are applying a great deal of R&D effort to ensure that the cables can be produced and that the layer 0 modules have adequate performance.

1.1.3.2.6. The unknown mechanism leading to failures in the CDF radiation accident raises concern about the sensitivity of the new design to high rates of radiation and to the possible existence of single points of failure.

1.1.3.3. Recommendations:

1.1.3.3.1. The committee encourages the groups to converge to a common technological solution for the layer 0 analog cables and to pursue this solution with multiple vendors. Noise suppression studies should continue in the short term. The groups should define a clear decision path and branch points to arrive at production. The quality of the cable needs to be monitored as closely as possible during production.

1.1.3.3.2. Complete stave failure modes should be clearly identified. The design should be analyzed in terms of these failure modes, trying to minimize their effect on overall performance. For instance, long daisy chains should allow break points, as the CDF Priority Bypass Chip solution, clock and control lines should have reasonable connection redundancy and what-if scenarios should be developed for foreseeable problems. The possible failure of the SVX4 chip in stressful conditions (such as high radiation rate, high temperature, etc.) should be examined and mitigated as much as possible.

1.1.3.3.3. The designs should be reviewed to eliminate single-point failures and to identify high-risk items such as connectors and couplings in the cooling system. These require special attention in long-term testing.

1.1.4. Quality Assurance

1.1.4.1. Findings:

1.1.4.1.1. Both experiments base their approach to testing and burn-in on their experience with the Run IIa detectors.

1.1.4.1.2. Both experiments have developed and presented a preliminary production QC/QA plan.

1.1.4.2. Comments:

1.1.4.2.1. The planned burn-in at low temperature can be contrasted with the approach taken in space sciences to burn-in the hybrids at elevated temperatures to eliminate infant mortality, and to subject the finished but unpowered ladders or staves to conditions below the operational temperature to find solder-joint and glue-joint problems due to thermal stress.

1.1.4.3. Recommendations:

1.1.4.3.1. The groups should develop a comprehensive QC/QA document describing the tests to be done on each component and on the assemblies. They should take into account the industry standard procedures in terms of elevated temperature reliability testing. Particular care should be devoted to performing as extreme a test as possible on each component prior to assembly. These may include low and high temperature cycles, mechanical stress tests, elevated temperature burn-in, and should be focused on provoking failure early in the assembly process, thus reducing the rework rate and increasing the reliability.

1.1.5. Mechanical structure and cooling

1.1.5.1. Findings:

1.1.5.1.1. The two groups are pursuing different solutions for the stave cooling tube material: carbon fiber for D0 and PEEK for CDF. The difference is mainly motivated by the different aspect ratio of the channels, deriving from the different structure of the staves. Both solutions seem well justified and viable, although some technical issues remain. CDF has previous positive experience with PEEK.

1.1.5.1.2. D0's carbon fiber solution also improves the rigidity of the stave. A large amount of investigation on the characteristics of the carbon fiber has been done.

1.1.5.1.3. CDF made good progress fabricating the fixtures for the module assembly. D0 is ready to fabricate the fixtures, but doesn't yet have them in hand.

1.1.5.1.4. The collaborations have been given new guidelines as to the bunch structure and the luminosity goals for Run IIb. The new baseline with 396 ns bunch spacing yields a longer luminous region than the original 132 ns option (28 cm vs. 15 cm). This will lead to a reduced tracking efficiency for D0 due to the shorter inner layer staves.

1.1.5.2. Comments:

1.1.5.2.1. Each cooling pipe solution has its own merits and problems. The carbon fiber long-term stability is not well known. In addition, being conductive, it will induce noise on the sensors, requiring an effective grounding scheme to minimize the noise.

1.1.5.2.2. PEEK is intrinsically much less rigid than carbon fiber, although its stability and radiation resistance are well known. Square to round transition points and gluing may pose reliability problems with this material. A carbon fiber solution could reduce the gravitational sag of the stave and increase the vibration frequency of its fundamental mode. Although CDF claims that 200 μm sag does not affect SVT capability, it is still a concern to us.

1.1.5.2.3. CDF experienced failure of the cooling interconnects in the ISL. This points to the need for both experiments to engineer carefully their cooling system and to leave ample time for long-term testing.

1.1.5.3. Recommendations:

1.1.5.3.1. The long-term stability of the carbon fiber tubes should be confirmed through accelerated aging tests. For the PEEK tubes the reliability of the square to round transition and of the glue connection should be measured. Long-term leak tests under pressure and thermal stress should be carried out.

1.1.5.3.2. CDF should evaluate the relative advantages and disadvantages of the carbon fiber solution.

1.1.5.3.3. The committee recommends that high priority be given to the fabrication of a mechanical stave to characterize mechanical, cooling capability and robustness against thermal stress, as well as other mechanical properties.

1.1.5.3.4. D0 should conduct further studies on the impact of the 396 ns option and consider increasing the length of the inner layers to recover the efficiency loss.

1.1.6. Management and schedule

1.1.6.1. Findings:

1.1.6.1.1. The two collaborations attempted to reconcile and/or understand differences in their cost and manpower estimates. Nonetheless, D0's technical manpower estimate (130,000 hours) is about 60,000 hours higher than CDF's (70,000 hours).

1.1.6.1.2. D0 has shown a study of schedule sensitivity to slippage of intermediate tasks. Most task slippage has apparently little impact on the project end date.

1.1.6.2. Comments:

1.1.6.2.1. Both teams show adequate management structure, although it is not clear if the configuration control is adequate. D0 has all level 3 managers named and in place, while CDF has only subsystem managers.

1.1.6.2.2. The committee did not have enough time to examine the manpower estimate in details and to understand whether the differences and the absolute values are well justified.

1.1.6.2.3. The committee understands that the manpower available at Sidet during the silicon upgrades might not be sufficient to satisfy the needs of all the FNAL silicon projects.

1.1.6.2.4. The schedule sensitivity shown by D0 has only limited interest, since no leveling was applied, and likely the resources in the varied schedules are over-allocated.

1.1.6.3. Recommendations:

1.1.6.3.1. The two collaborations should continue to work on the budget and manpower comparison to identify the causes for the differences, and to justify them.

1.1.6.3.2. CDF should name the level 3 managers as soon as possible.

1.1.6.3.3. Schedule sensitivity should be analyzed by both experiments including manual or automatic leveling of resources.

1.1.6.3.4. The groups should define a clear process through which the design of parts is approved before starting production or procurement. This process may include sign-off procedures, final design reviews, production readiness reviews. This is urgent for those parts that need to be ordered soon. In some cases such procedures may already be in place.

1.1.6.3.5. The cooperation between the experiments on crucial technical issues should continue and be reinforced. Commonality of the two designs has already been well exploited but continuing collaboration during construction is crucial to ensure a timely completion of the project.

1.2. CDF Calorimeter Upgrades

1.2.1. Central Preradiator Upgrade

1.2.1.1. Findings:

1.2.1.1.1. The TDR describes convincingly the need for replacing the Central Preshower Detector. It also describes the structure of the proposed detector in about 1.5 pages. The TDR is accompanied by a 12-page WBS dictionary and twelve milestones are indicated in the Gantt chart for the task. The cost of this upgrade is estimated to be $700K plus 30% contingency, although costs given in the presentation were not the same as in the WBS dictionary which was made available on the web.

1.2.1.2. Comments:

1.2.1.2.1. The physics case for the upgrade appears to be well justified and the technical risks are minimal.

1.2.1.2.2. There is no indication of any technical drawings associated with the design. Because of this it is difficult to know how the phototubes are mounted and how the fibers are routed. No prototype studies of the baseline design are presented.

1.2.1.2.3. The TDR does not address the issue of the performance of the multi-anode PMTs in the return field of the solenoid magnet. In discussion, however, the proponents indicate that they are already operating these PMTs in similar field conditions.

1.2.1.2.4. Many tasks in the WBS dictionary have no time duration. For example, the R&D task requires $101K but is completed in one day. There is no indication of the deliverables from the R&D work.

1.2.1.3. Recommendations:

1.2.1.3.1. This task would be strengthened by more evidence of engineering work in planning the design. The TDR indicates that prototype studies using the Dubna scintillator are underway. Any quantitative preliminary results from this work would be useful.

1.2.1.3.2. A statement should be added to the TDR on experience with these phototubes in similar magnetic field conditions.

1.2.1.3.3. The costs given in the WBS dictionary should be reconciled with those given in the presentation.

1.2.1.3.4. This task is ready to baseline, although the documentation would benefit from the additions just mentioned.

1.2.2. EM Calorimeter Timing

1.2.2.1. Findings:

1.2.2.1.1. The TDR describes the need for a timing measurement from the 960 PMTs of the central EM calorimeter and 768 PMTs of the plug EM calorimeter. The technical aspects of the work are described in about 1.5 pages, There is a clear description of the inductive splitter, its negligible effect on the calorimeter energy measurement, and the time resolution obtained using an LED signal. The TDR is accompanied by a 13 page WBS dictionary. The total cost of this upgrade is estimated to be $250K plus 30% contingency.

1.2.2.2. Comments:

1.2.2.2.1. The scope of this task appears to be clearly defined and a working solution has been demonstrated.

1.2.2.2.2. This does not appear to be an upgrade of the highest priority but it would certainly strengthen the characteristics of the detector.

1.2.2.3. Recommendations:

1.2.2.3.1. This task appears ready to baseline.

1.3. CDF Trigger/DAQ Upgrades

1.3.1. General Comments on CDF Trigger Upgrades

1.3.1.1. Findings:

1.3.1.1.1. The Run IIa CDF trigger design is sound and presents a well defined upgrade path for Run IIb operation.

1.3.1.1.2. The maximum rates at each of the three trigger levels in the proposed Run IIb system are as follows:

- Level-1 accept: ~50kHz
- Level-2 accept: ~1kHz
- Level-3 accept: ~85Hz

1.3.1.1.3. Extrapolations performed by the CDF trigger group indicate that the proposed Run IIb trigger system will function well at a luminosity of 4×10^{32} /cm^2/sec with 396 ns bunch spacing.

1.3.1.2. Comments:

1.3.1.2.1. The CDF detached vertex trigger has demonstrated impressive performance under the present Run IIa conditions.

1.3.1.2.2. The CDF scheme for incremental installation and testing is commendable.

1.3.1.2.3. If a luminosity of 2×10^{32} /cm^2/sec is reached at the end of Run IIa, the present CDF trigger and DAQ systems may be operating near or beyond their design capacity.

1.3.1.2.4. Commissioning the proposed Run IIb trigger system will require significant manpower resources as well as careful co-ordination between the trigger group and all other detector components, most notably data acquisition. Although a general installation plan is in place, careful consideration should be given to the details of the commissioning effort as the Run IIb projects evolve.

1.3.1.3. Recommendations:

1.3.1.3.1. Estimates of various trigger line rates for Run IIb conditions use current performance figures extrapolated linearly to higher luminosity. To verify these extrapolations, the CDF trigger group should also consider using simulated events for high luminosity conditions which include multiple interactions per bunch.

1.3.2. XFT Upgrade

1.3.2.1. Findings:

1.3.2.1.1. The CDF Run IIb Level-1 track trigger, which the proponents call the extremely Fast Tracker (XFT), is an upgraded version of the track trigger designed for Run IIa. The new design preserves the general architecture of the Run IIa track trigger.

1.3.2.1.2. Since roughly 50% of all physics triggers involve tracks from the XFT, it is crucial to overall system performance.

1.3.2.1.3. The upgraded XFT derives its main performance gain by exploiting a factor-of-three improvement in the precision of the timing information transmitted from the upgraded TDCs to the XFT. This reduces the effective size of the trigger elements, leading to a reduction in fake tracks and an improvement in the P_t and φ_0 resolution.

1.3.2.1.4. The system also incorporates stereo information, which further reduces the rate for fake lepton triggers. This feature would be particularly crucial if the collider were to run at 132 ns, which would eliminate the factor-of-three timing advantage cited above.

1.3.2.1.5. The overall effort required for the XFT is significant, involving roughly 70 complex PC boards and at a total estimated cost of \$2.6M dollars. Significant effort has already been expended on many design details of the XFT. However, it appears that a considerable amount of work remains on printed circuit board design and firmware development.

1.3.2.2. Comments:

1.3.2.2.1. A successful upgrade of the XFT track trigger is essential to successful operation of CDF during Run IIb, as has been presented by the proponents. Their simulations show a rapid deterioration in P_t and φ_0 resolution as well as a rapid increase in fake rate as the number of interactions per crossing increases.

1.3.2.2.2. The XFT design appears to be sound and is sufficiently well advanced to be credible. Although the committee did not examine costs and technical risks in detail, the proposed design appears to be within the state of the art and is sufficiently well defined to be reliably costed. There is some indication from comparison with similar systems that the cost estimates may be on the high side.

1.3.2.2.3. Complete confidence in the design can only be gained through use with realistic signals from the detector.

1.3.2.3. Recommendations:

1.3.2.3.1. The proponents should further validate the upgraded XFT design by studying its performance using a software emulation based on Run IIa data and/or (if possible) by testing prototype boards with actual signals from the detector.

1.3.2.3.2. The committee feels this task is ready to baseline.

1.3.3. TDC Replacement for the Central Outer Tracker

1.3.3.1. Findings:

1.3.3.1.1. The current TDC modules used for the COT will seriously limit the ability of the CDF detector to take data at Run IIb rates for several reasons:

- Hit processing is performed only after a Level-2 accept, hence the total processing plus readout deadtime associated with a Level-2 accept is too large.
- The readout of the TDC buffers via VME block transfer is too slow.
- Data transfer out of the TDC crates via TAXI is too slow.

1.3.3.1.2. The current modules do not provide the information needed by the proposed XFT upgrade.

1.3.3.1.3. The proposed TDC upgrade provides an elegant solution to all of these problems. The time to digital conversion, hit processing, buffering, and readout can be implemented in a single Altera Stratix FPGA.

1.3.3.1.4. The cost of this task is approximately $1.67M, which includes 33% contingency.

1.3.3.2. Comments:

1.3.3.2.1. The committee feels the CDF trigger group is pursuing the correct solution to this problem and that the proposed upgrade should be implemented.

1.3.3.3. Recommendations:

1.3.3.3.1. The committee feels this project is ready for baselining.

1.3.4. Level-2 Decision Crate

1.3.4.1. Findings:

1.3.4.1.1. The estimated cost for this item is $215K plus 30% contingency for M&S.

1.3.4.1.2. The proposed replacement of the Level-2 decision crate addresses the need for increased bandwidth and computing power for the Level-2 trigger system. It is proposed to replace the Level-2 systems by newly developed electronic boards, which have been developed in the context of the Level-2 test-stand (Pulsar system).

1.3.4.1.3. The proponents list additional reasons to do this upgrade, pointing out that the currently employed alpha processors do not provide a viable hardware platform for the longer term, and that the current diversity of interface boards to the front end electronics poses serious maintenance issues.

1.3.4.1.4. The proposed new boards have a common design for all systems, with small interface boards specific to each detector component. The design makes use of standard commodity PCs to provide CPU power, instead of using embedded CPUs. It also uses the S-LINK bus system developed and implemented at CERN and used by Atlas.

1.3.4.2. Comments:

1.3.4.2.1. This approach appears reasonable. It provides a simplification of the system and a clear upgrade path for the increased needs for processing power.

1.3.4.2.2. However, no specific study was presented justifying the specific design and performance. The documentation provided in the TDR is very abbreviated and involves less than a page of text. It is beyond the scope of this review to look in detail into the design, implementation, costs and risks.

1.3.4.3. Recommendations:

1.3.4.3.1. Because of the limited information available a review of the technical solution, cost estimate, and schedule still remains to be done. The committee recommends that the project provide a more detailed report in the future. For the time being, the resources for this upgrade should become part of the "project trust fund" recommended by the PAC.

1.3.5. Event Builder Switch

1.3.5.1. Findings:

1.3.5.1.1. The cost estimate for this item is \$414K + 30% contingency. The estimate only considers the equipment costs to upgrade existing hardware and to provide spares.

1.3.5.1.2. The upgrade is to increase the bandwidth of the system and hence to accommodate the higher rates and larger event sizes of Run IIb operation. The required bandwidth is estimated to be at least 250 Mbytes/second.

1.3.5.1.3. The current CDF Event-Builder consists of a 32 port OC3 ATM switch with a bandwidth limit of 240 Mbytes/s. About 60% of that bandwidth has been achieved in benchmark tests using simulated event sizes of Run IIb. It is possible that up to 80% of the theoretical limit could be achieved after tuning the system.

1.3.5.1.4. CDF proposes to upgrade the switch to provide OC12 ATM links. This would increase the throughput of the system to a theoretical limit to 1 Gbyte/s.

1.3.5.2. Comments:

1.3.5.2.1. The committee did not hear any evaluation of alternatives to the proposed solution, such as replacing the ATM switch with a Gigabit Ethernet switch. D0 has successfully implemented such a system, and this approach may be feasible, cost effective and would remedy issues with the ATM interfaces on the processing nodes.

1.3.5.2.2. It is noted that the OC12 (and OC3) interfaces on Linux computers are not commodity items. The development and integration of these drivers and their upgrade to accommodate new versions of Linux requires a high level of expertise. CDF has currently decided to freeze the Linux version on their event builder nodes because of incompatibilities of the OC3 interface drivers with the latest kernel versions. It will be important to keep open the option of upgrading to more recent versions of the kernel if one wishes to be able to use modern higher performance hardware.

1.3.5.2.3. The committee feels that this poses a significant risk to the project which has not yet been adequately addressed. There is a possible need for a significant software effort to modify and integrate drivers for OC12 which has not been accounted for in the project costs. The group proposes using students for this work. Since individual students only remain with the project for a limited time, it will be important to ensure that the code they produce can be maintained by others.

1.3.5.3. Recommendations:

1.3.5.3.1. The committee recommends an explicit assessment of this issue. The risks related to these issues should be elaborated and a mitigation plan proposed.

1.3.5.3.2. All related efforts and costs, including software and integration, should be tracked by the project, and thus be included in the WBS and schedule (WBS item 1.3.4.1), even if some of the effort is entered as zero-cost items.

1.3.5.3.3. This task is ready to baseline but before procurement other technical solutions should be examined.

1.3.6. Level-3 Processor Farm

Findings, comments and recommendations in these paragraphs concern both D0 and CDF, and are presented here for both experiments.

1.3.6.1. Findings:

1.3.6.1.1. The Run II Level-3 systems of D0 and CDF are scalable farms of Linux PCs, allowing the experiments to make use of commodity hardware for compute nodes, networking infrastructure and data storage. The committee commends D0 for their very successful effort in bringing their commodity hardware Level-3 system into operation.

The designs for the Level-3 systems allow a straight-forward upgrade to increase the throughput and processing power. Replacing older compute nodes with new higher-performance commodity hardware will take advantage of Moore's law to obtain the required performance increase. The committee in general agrees with the need for regular upgrading the systems during Run IIa. This will provide the necessary computing power at the start of Run IIb.

The estimated computing needs for Run IIb are based on a linear scaling of the current processing needs to the Run IIb situation with multiple interactions per bunch crossing. CDF and D0 are starting from quite different processing needs. This leads to the estimated Run IIb requirement of 6 CPU seconds per event for CDF, and 1.5 CPU seconds per event for D0, on a 1 GHz Pentium III. There is the assumption that CPU performance will continue to increase by a factor of about 1.7 each year.

CDF proposes to arrive at the required level of performance by upgrading 85 nodes each year in FY03, FY04 and FY05, with estimated costs of $390K plus 30% contingency.

D0 proposes to upgrade 32 nodes in FY04 and 64 nodes in FY05, at a total cost of $210K plus 70% contingency.

1.3.6.1.2. CDF does not foresee any upgrade of other DAQ-related computing systems as part of the scope of this project, although they will certainly be needed. The committee was informed that CDF considers those costs to be part of regular computing upgrades funded as operating expenses for Run IIa.

D0, on the other hand, proposes an upgrade of DAQ-related computing systems, including data base servers and data storage servers. The cost of these for D0 is $247K plus 50% contingency.

1.3.6.2. Comments:

1.3.6.2.1. The committee notes that if both experiments targeted their Level-3 upgrades solely for Run IIb, they would probably procure all processors as late as possible. That would allow CDF to obtain 1.8 times the performance at equal costs, or to decrease the costs by 60% with the corresponding benefit of being able to reduce the size of the system.

1.3.6.2.2. This committee was unable to look in detail at the proposed technical solutions, validity of approach and estimated costs. It feels that D0 estimated costs for the "host systems" upgrade are relatively high for providing a rather moderate, although highly available storage system of about 5TB and two data base servers. Those costs, like the costs for the farm upgrades, could probably be lower if the upgrades were targeted to 2006, instead of being available already in FY04.

1.3.6.2.3. The committee does not disagree with the claim that computing upgrades in the DAQ area will be needed already for the expected increase in luminosity and rates of Run IIa.

1.3.6.2.4. The use of commodity systems for Level-3 and DAQ has resulted in large similarities between the computing systems used for online and offline. The expected rise in Level-3 output rates and the increase in event size because of higher detector occupancies will have an important impact on the need for offline computing and data handling systems. These needs include network throughput and physics analysis resources at outside institutes. The increased resource requirements will not be a step function with the start of Run IIb but will rise progressively during Run IIa as luminosity increases.

1.3.6.3. Recommendations:

1.3.6.3.1. The committee feels that the experiments have not yet created a plan reconciling both the need for upgrades during Run IIa and the provision of computing power for Run IIb. It recommends developing such an integrated plan for computing upgrades taking into account both needs and thereby optimizing the use of resources.

1.3.6.3.2. The committee recommends that software and computing issues both in online (DAQ and Level-3) and in offline be addressed by a separate standing Run IIa/b computing review committee.

1.4. CDF Installation

1.4.1. Findings:

1.4.1.1. The present installation plan is described in about 2/3 of a page in the TDR. An installation time of 34 weeks is called for, including 50% contingency. The task is supported by a 27 page WBS dictionary. The estimated cost is $768K plus a contingency of $502K. The work requires an average of 17 FTEs over its duration and is based on a 40-hour week.

1.4.2. Comments:

1.4.2.1. The installation manager and his team are highly experienced and appear to be fully able to organize and complete the work. The present description in the TDR, however, is quite abbreviated. The presentation to the committee was much more informative and complete.

1.4.2.2. No Level 3 managers are identified for this task.

1.4.2.3. No profile of the manpower is shown over the duration of the task.

1.4.2.4. Planning is needed of the ramp-up of the installation process. An effort should be made to minimize simultaneous responsibility of individuals for both finishing the construction and planning installation.

1.4.3. Recommendations:

1.4.3.1. It would strengthen the TDR to include a summary of the tasks to be done and a monthly breakdown of the manpower required, according to type.

1.5. D0 Level-1 Trigger Upgrades

1.5.1. General Comments: related to the D0 Trigger

1.5.1.1. Findings:

1.5.1.1.1. The maximum rates at each of the three trigger levels in the proposed Run IIb system are as follows:

- Level-1 accept: ~5kHz
- Level-2 accept: ~1kHz
- Level-3 accept: ~50Hz

1.5.1.1.2. For D0 the acceptable rate from Level-1 is approximately an order of magnitude lower than for CDF.

1.5.1.2. Comments:

1.5.1.2.1. The Run IIa D0 trigger design appears able to meet its technical specifications and represents a reasonable basis for the Run IIb upgrade.

1.5.1.2.2. Despite this, if a luminosity of 2×10^{32} /cm^2/sec with 396 ns bunch spacing is reached near the end of Run IIa, the present D0 trigger and DAQ systems may be near the limits of their design capacity.

1.5.1.2.3. Simulations and extrapolations performed by the D0 group indicate that the proposed trigger upgrade for Run IIb will function well at a luminosity of 2 x 10^{32} and 396 ns. The committee accepts their conclusion.

1.5.1.2.4. Early deployment of some of the upgrades could help late in Run IIa if the luminosity is high.

1.5.1.2.5. The D0 scheme for incremental installation and testing is commendable.

1.5.1.2.6. Studies for a luminosity of 4×10^{32} /cm^2/sec and a bunch spacing of 396 ns indicate that some of their trigger components, most notably the high P_t track trigger, may again be very close to their operational limit. This represents potential scope risk and needs to be examined further. In particular, the performance of the Level-2 silicon tracker, which is an important part of their trigger, needs to be simulated under these conditions. Since the issue is associated with headroom beyond the baseline luminosity we believe it should not impact baselining the project. The contingency might reflect this risk.

1.5.1.3. Recommendations:

1.5.1.3.1. The D0 Level-2 and Level-3 trigger algorithms for Run IIb have not yet been finalized. Some of this software will be developed during Run IIa, but substantial additional effort will be needed for Run IIb. We recommend that an explicit plan be developed for producing the Level-2 and Level-3 trigger algorithms and associated software tools.

1.5.2. Level-1 Tracking Trigger

1.5.2.1. Findings:

1.5.2.1.1. The Run IIb Level-1 track trigger, which employs hits from the charged fiber tracker (CFT), is an upgraded version of the L1CTT trigger designed for Run IIa.

1.5.2.1.2. Since almost all physics triggers involve the combination of information from another detector subsystem with tracks from the L1CTT, it is crucial to overall system performance.

1.5.2.1.3. The new design preserves the general architecture of the Run IIa design and derives its main performance gain from the use of single fiber hits, as opposed to the doublets employed in the Run IIa design. Implementation of this logic involves a substantial amount of new hardware (M&S costs of $1.1M, including contingency) primarily for replacing the 80 daughter boards that implement the L1CTT logic.

1.5.2.1.4. Significant effort has already been expended on many design details of the upgraded L1CTT. For example, the group is well advanced in defining the logic and establishing the capacity of the field programmable gate arrays required to implement it. Results of reasonably detailed physics simulations were presented which showed improvements in rejection of more than an order of magnitude relative to Run IIa.

1.5.2.2. Comments:

1.5.2.2.1. A successful upgrade of the L1CTT track trigger is essential to successful operation of D0 during Run IIb. This comment is supported by simulation data presented by the proponents, which show a rapid degradation in performance of the current system even at modestly increased occupancies, such as those that may be encountered near the end of Run IIa.

1.5.2.2.2. The L1CTT design appears to be sound. The design is sufficiently well advanced to be credible. Additional confidence would come from more detailed studies based on the superposition of real minimum bias events.

1.5.2.2.3. Although the committee did not examine costs and technical risks in detail, the proposed design appears to be within the state of the art and is sufficiently well defined to be reliably costed.

1.5.2.3. Recommendations:

1.5.2.3.1. The proponents should further validate the upgraded L1CTT design by studying its performance using a software emulation based as closely as possible on Run IIa data but with multiple events superimposed as expected for the conditions of Run IIb.

1.5.2.3.2. This subsystem appears ready to baseline.

1.5.3. Level-1 Calorimeter Trigger

1.5.3.1. Findings:

1.5.3.1.1. The D0 Level-1 calorimeter trigger is based on signals from 1280 EM towers and 1280 hadronic towers, each 0.2×0.2 in η and φ.

1.5.3.1.2. The input signals to the trigger are rather slow, with a 150 ns rise time and 400 ns width. This makes their association with a given bunch crossing difficult for a 132 ns bunch crossing time. Operation at 396 ns is more straightforward.

1.5.3.1.3. The calorimeter tower size for the trigger is currently much smaller than the characteristic size of a hadronic jet. This leads to a very slow turn on of the jet trigger efficiency as a function of E_t. For example, to obtain 100% efficiency for a 60 GeV jet requires a tower threshold of only 6 GeV. The result is a Level-1 jet trigger dominated by low energy jets. The efficiency for electrons and photons is similarly degraded for impact points near tower boundaries. The proposal is to implement a sliding window algorithm and a larger jet tower size to sharpen the trigger threshold.

1.5.3.1.4. The center of a jet is estimated by a sliding window of 0.4×0.4 over the trigger towers to locate local maxima. The jet energy is estimated by summing over a region of 0.8×0.8 centered on a maximum found by the sliding window.

1.5.3.1.5. The result is that for a setting which gives 85% efficiency for jets above 40 GeV, the trigger rate is reduced by a factor of 3. The electron trigger is similarly strengthened. The performance for particular channels of Higgs production is shown.

1.5.3.1.6. The design includes the capability to add signals from the inter-cryostat detectors into the energy trigger to further improve resolution. It also introduces the possibility of enriching the trigger in τ leptons through the presence of a very narrow jet in the calorimeter.

1.5.3.1.7. The TDR contains 83 pages describing the principles of operation, the performance, and the implementation details of this upgrade. The schedule is described in a 92-line Gantt chart with 9 high-level milestones. The cost of this upgrade is $1.3M, including 43% contingency.

1.5.3.1.8. Saclay, Columbia, and Michigan State propose to take the lead responsibility for the task.

1.5.3.2. Comments:

1.5.3.2.1. The TDR contains extensive detail on studies done to explore and optimize the performance of the system, as well as on the design. The proponents would be well served if they could characterize, relative to the Run IIa trigger, the improvement brought by this upgrade to the overall significance of the Higgs signal. Other global performance figures would also be helpful to make clear the impact of this upgrade.

1.5.3.2.2. The proponents have indicated in response to questioning that elimination of the digital filter, which is less critical for 396 ns operation, would save less than $50K since FPGAs are needed in any case to format the data for the TAB boards which perform the sliding window calculation.

1.5.3.2.3. The three principal institutions all have extensive experience with complex trigger systems.

1.5.3.2.4. The proponents indicate that they plan to test parts of the new system during Run IIa using signals from the present detector. We view this as a very valuable process.

1.5.3.3. Recommendations:

1.5.3.3.1. The proponents should try to characterize the performance of the upgraded system with a few global figures of merit. The PAC has emphasized the Higgs detection significance.

1.5.3.3.2. This task appears ready to baseline.

1.5.4. Calorimeter-Track Matching Trigger

1.5.4.1. Findings:

1.5.4.1.1. The high rate of fake tracks and showers becomes a problem as luminosity increases. D0 studies have shown that at high luminosity the proposed Level-1 track-shower matching system will reduce the rate of false medium P_t electron triggers by a factor of two or three. It can also be used to reject fake tracks by a factor of one to two orders of magnitude.

1.5.4.1.2. The proposed Cal-Track design combines information from the upgraded CFT track trigger as well as the upgraded calorimeter trigger to correlate in φ hits between the two. The proposed design uses the fact that an eight-fold increase in φ granularity will be available from the proposed calorimeter upgrade.

1.5.4.1.3. The system exploits the existing design for a similar system used to correlate CFT tracks with hits in the muon system. The use of an existing design minimizes both the cost and risk of the proposed upgrade.

1.5.4.1.4. The cost of this project is approximately $260K, which includes 31% contingency.

1.5.4.2. Comments:

1.5.4.2.1. While the D0 collaboration has not explicitly made the case that the Cal-Track project is needed in order to successfully pursue a high P_t physics program, the committee feels that this upgrade is a prudent and cost-effective measure given that the overall trigger system may be struggling to provide adequate rejection at the highest Run IIb luminosities. In particular, this system could be a key ingredient in keeping the rate of high P_t track triggers to a tolerable level at luminosities above 2×10^{32} /cm^2/sec, where 6 or more minimum bias events are expected from each crossing and fake track trigger rates are a potential problem.

1.5.4.3. Recommendations:

1.5.4.3.1. The committee feels this project is ready to baseline.

1.6. D0 Level-2 Trigger Upgrades

1.6.1. Level-2 Beta Trigger

1.6.1.1. Findings:

1.6.1.1.1. The presented project cost is $64K including 30% contingency. No Fermilab labor has been assigned to this item.

1.6.1.1.2. The system will already be commissioned for Run IIa, where it will replace the current Level-2 alpha boards. The group is expecting to obtain pre-production Level-2 beta boards with current-generation (commercially available) processor boards for Run IIa. They will commission the system with about 26 boards this year, completely replacing the existing Level-2 alpha boards.

1.6.1.1.3. The specified costs for this project are solely for upgrading 12 of the CPU boards to provide increased processing power to the Level-2 trigger.

1.6.1.2. Comments:

1.6.1.2.1. Although the Level-2 computing boards were a high-risk item for Run IIa, the committee feels that this project presents only moderate risk for Run IIb.

1.6.1.2.2. It is, however, of central importance for the D0 upgrade to achieve the goals for the Level-1 and Level-2 output rates. This will require the rejection of substantially increased backgrounds, specifically from the tracking triggers. With the Level-1 upgrade many of the current Level-2 cuts will be moved to the Level-1 trigger. D0 will need to develop a new set of Level-2 algorithms to keep the Level-2 output rate below 1 kHz.

1.6.1.2.3. General ideas for revised Level-2 algorithms were presented, such as moving the vertex finding to Level-2. The exact effectiveness of these cuts over Level-1 will need to be studied. The required increase in CPU performance needs to be estimated and a method devised to parallelize the processing on several nodes.

1.6.1.2.4. The committee finds that most of the effort in this item is in providing the necessary physics algorithms on the Level-2 processors. This effort is not spelled out in the project, but its success is essential for the success of the Level-2 project. Currently the Level-2 software effort consists of a reasonable sized group of 6-8 physicists. The project will need to track this effort.

1.6.1.3. Recommendations

1.6.1.3.1. Upgrading the single board computers as this task proposes represents a clear path towards obtaining the required processing power. However, the committee has not seen detailed studies on what resources are needed to obtain the required cut in Level-2 rate. Thus the cost estimates, which foresee replacing 12 of the boards for Run IIb, should be considered somewhat preliminary, and contingency should be foreseen in case more CPU resources are needed.

1.6.1.3.2. The committee would like to see a Level-2 trigger report as a milestone, where simulation studies and tests are compiled to show the rejection power of the Level-2 for Run IIb running. The report should address the required processing power and bandwidth, and outline a plan for providing the required Level-2 software.

1.6.1.3.3. The committee feels that the proposed solution is reasonably straight forward and cost effective and is ready to baseline.

1.6.2. Level-2 Silicon Track Trigger

1.6.2.1. Findings:

1.6.2.1.1. The Silicon track trigger (STT) is a Level-2 trigger preprocessor that combines information from the silicon microstrip tracker and the Level-1 fiber tracker and produces high resolution momentum and impact parameter information for each track candidate. Since information is correlated between two independent detector systems the rate of fake tracks is also reduced. The cost of this project is approximately $329K including 43% contingency.

1.6.2.2. Comments:

1.6.2.2.1. The STT is a key component of the D0 trigger system. It plays an important role in all physics trigger lines and is the key ingredient in lines using detached vertices to tag b-jets.

1.6.2.2.2. Since the Run IIa version of the STT will be commissioned during the next six months, verifying that the present device functions within design specifications should be a key milestone in the execution of the Run IIb system.

1.6.2.3. Recommendations:

1.6.2.3.1. The performance of the STT trigger at the highest proposed Run IIb luminosities with a bunch spacing of 396 ns should be studied further using the same detailed simulations used to validate the design for operation with a bunch spacing of 132 ns. These studies, combined with the experience from commissioning the STT for Run IIa, should be used to guide the Run IIb STT project.

1.6.2.3.2. The committee feels this project is ready to baseline.

1.7. D0 DAQ/Online Upgrades

See comments under 1.3.6 where these issues are discussed for both CDF and D0.

1.8. D0 Installation

1.8.1. Findings:

1.8.1.1. The main installation work involves replacing the D0 silicon. This operation involves steps similar to those carried out during the Run IIa installation and therefore can be planned with reasonable certainty. During this operation the detector will remain on the beamline, unlike the situation for silicon installation in Run IIa.

1.8.1.2. The installation team estimates that a total of 30 weeks will be required from the time the Tevatron stops until the detector is closed. The cost of the effort is $1.3M, including contingency, and a team of 45 (peak) physicists, engineers, and technicians. The average manpower requirement is 24 FTEs.

1.8.2. Comments:

1.8.2.1. An appropriately detailed and credible plan was presented for the installation. A management team has been named. Although the current installation team is somewhat understaffed, the proponents argue that additional experienced manpower will become available as the construction part of the project winds down.

1.8.3. Recommendations:

1.8.3.1. The group should revisit the installation plan as the date approaches and the construction efforts are completed. At that time the individuals available will be clearer. It will be important to minimize additional responsibilities of the management personnel trying to complete construction tasks.

2. Cost, Schedule, Management Subcommittee Report

2.1. Cost and Schedule Section Common to Both Detectors

2.1.1. Overall Assessment

2.1.1.1. Findings

2.1.1.1.1. Both the CDF and D0 Run IIb management teams have selected and are using project management software for cost and schedule planning. Microsoft Project 2000 is the schedule and resource tool, with COBRA as the cost and earned value tool.

2.1.1.1.2. While the CDF and D0 Run IIb projects are distinct efforts, there has been a concerted effort to provide an economy of scale when technically applicable. This effort is seen in the use of a common readout chip (SVX4), the essentially identical specifications for the silicon wafers, and a common technology for the hybrids (ceramic).

2.1.1.1.3. Although there are differences in confidence level, each project has a defined set of sources for all of the major components.

2.1.1.1.4. The procedures necessary to report and track effort at Fermilab have not been established between the project offices, the Particle Physics Division, and Fermilab management.

2.1.1.1.5. Both CDF and D0 Run IIb management teams presented risk analyses.

2.1.1.1.6. Neither project team presented specific plans for configuration control.

2.1.1.1.7. The non-silicon project scope is well defined.

2.1.1.1.8. While most systems do not have a "final" design, many are similar to systems built for RUN IIa. The technical solution is almost always known. There is a good understanding of how each component will be acquired.

2.1.1.1.9. The WBS's of non-silicon project are complete, in the sense:

2.1.1.1.10. That there seem to be adequate stages of development – one or more prototypes and pre-production stages, which seem appropriate to the complexity of the modules.

2.1.1.1.11. Due attention is paid to all design and specification steps.

2.1.1.1.12. Provision is made for programmers of firmware, people to perform and evaluate tests etc.

2.1.1.2. Comments

2.1.1.2.1. Both the CDF and D0 Run IIb management teams have made significant progress in their cost and schedule planning since the April 2002 Director's Review. Additionally, both teams are to be commended for their frank discussion of the issues and challenges that they see ahead.

2.1.1.2.2. There is a need to establish an effort reporting system that can satisfy the needs of the projects to do timely cost tracking and effort reporting. The "Review of the Manpower Requirements at the Silicon Detector Facility for Run IIb and CMS" (June 2002) also cited this issue.

2.1.1.2.3. Current planning calls for G&A funds to be managed by Fermilab management. The process by which the G&A is estimated and the subsequently levied against the projects have not been fully described or understood by the management teams. Furthermore, the project management offices should be aware of the benefits they derive from the G&A contribution to Fermilab, and peoplepower options available to them to optimize their performance against the schedule.

2.1.1.2.4. There was significant discussion in the project teams' presentations on change control and levels of authority for each management step, from DOE on down to the group managers' level. It did not appear that this system had solidified as yet. In addition, even as the change control process is agreed to, their needs to be more technical background work before an issue gets into the change control process. This work can be described as configuration control. Change control process can be obliterated and become dysfunctional if inundated with numerous requests for change. The sifting process is configuration control that sorts out what issue deserves to be fed into the change process. This can be as simple as deciding that there are regularly scheduled meetings among the members of the project team to discuss issues relating to their respective systems and how those issues affect each of them.

2.1.1.2.5. The scope is very well defined and unlikely to change It is driven by the requirements of doing high Pt physics at the baseline luminosity, is constrained by the detector configuration after the upgrade and the DAQ architecture, neither of which is changing that much.

2.1.1.3. Recommendations

2.1.1.3.1. None in this Section.

2.1.2. Total Project Cost Estimates

2.1.2.1. Findings

Silicon Costs	M&S	M&S Cont.	Labor	Labor Cont.
D0	8.1 M$	4.8 M$	3.9 M$	2.1 M$

CDF	7.6 M$	3.5 M$	2.5 M$	1.1 M$

2.1.2.1.1. The labor estimate for Silicon is almost a factor 1.7 larger for D0 than CDF. The scope of the detectors is relatively similar (as demonstrated by roughly identical M&S costs). CDF estimated approximately 72,000 hours of technical labor versus the D0 estimate of 131,000 hours.

2.1.2.1.2. In breaking out M&S and labor costs, university labor is defined as an M&S cost in the project files.

2.1.2.1.3. The non-silicon cost estimates seem to be realistic because;

- in many cases, the upgrade projects are replacements of or similar to systems built for RUN IIa;
- in those cases, labor is derived from actual experience of calendar time taken and implicitly includes many real-world effects that would be neglected in a "time-and-motion" type estimate. In many cases, the manpower is in place and is often the same people who did the work in RUN2a;
- parts are usually from quotes. Where extrapolations seem risky, contingency has been added to cover the uncertainty.

2.1.2.2. Comments

2.1.2.2.1. In the view of the committee, a 'historical cost estimate', based upon earlier silicon detector construction projects at Fermilab (with the appropriate scaling), would have provided a more reliable assessment of the real 'cost of doing business' at Fermilab. In the absence of this, 'top-down' comparisons of the US CMS EMU and US CMS HCAL Fermilab projects were studied to look for agreement in Labor/M&S ratios. Labor included all 'thinking labor' (EDIA-Engineering, Design, Inspection & Administration) costs. For US CMS EMU labor was ~50% of the total construction cost, and US CMS HCAL was ~40%. The D0 and CDF Run2B projects have ratios of labor versus total construction costs of ~33% and ~25% respectively. Furthermore, comparing EDIA between the two projects, we find the CDF ratio to be almost a factor of two lower than the D0 project. Based upon this admittedly rough assessment, the committee believes that the D0 labor estimate is more predictive of the anticipated labor costs.

2.1.2.2.2. Comparing the labor of the two projects at the lowest WBS level the committee found a few tasks providing ~10,000 hours of difference that could be justified based on different 'make/buy' approaches of the management teams. The remainder of the labor disparity is unclear. This must be understood prior to the baseline review.

2.1.2.2.3. With regard to each silicon upgrade project's cost and contingency estimates, the committee has the following comments for consideration;

- The D0 Sensors (WBS1.1.1) base cost should be increased by \$150k (with 55% contingency) to provide the additional sensors for a 396nsec bunch spacing.
- The D0 sensors (WBS 1.1.1) contingency of 75% is not warranted given that a technical specification exists and CDF now has prototypes. A contingency on sensors of 55% seems more in line with the risk, bringing the overall contingency for WBS 1.1.1 to ~50%.
- A contingency of 55% for CDF sensors (WBS 1.1.1), rather than the current 30%, might better reflect the risk due to \$/Yen uncertainties.
- The CDF Labor/M&S ratio would be more in line with earlier Fermilab projects with ~\$1.1M added to its base cost. Additionally, given the lower number of base-supported physicists on the CDF upgrade, a 100% contingency on the ~\$1.1M might provide the necessary resources, should the need to purchase peoplepower become necessary.

2.1.2.2.4. With university labor costs grouped together in the project files with M&S costs, it is unnecessarily difficult to retrieve the real amount of labor and M&S in each of the projects.

2.1.2.2.5. Cost cross checks were made on the non-silicon projects by doing an independent estimate or comparing with personal experience and for the most part we concluded that the costs were reasonable.

2.1.2.2.6. A major issue arose. It was not clear whether contingency was included in the projects for "zero cost" labor. If zero cost labor is not actually available or lacks the skill or ability to do the job, then where is the contingency to supply professionals to complete the work?

2.1.2.3. Recommendations

2.1.2.3.1. Provide an explanation or correction to the current disparity in labor estimates between two projects of roughly the same technical scope and schedule.

2.1.2.3.2. Consider splitting the resource assignments in the Project files in order to account separately for labor and M&S provided by a University.

2.1.2.3.3. FNAL needs to determine how both projects are to handle contingency for non-costed labor.

2.1.2.3.4. Both projects should place a copy of their project's "standard method" for assigning contingency in the front of the WBS Dictionary/Cost books.

2.1.3. Schedule

2.1.3.1. Findings

2.1.3.1.1. Due to uncertainties with the Tevatron schedule, the beginning of installation of the tracker upgrades cannot be determined. As such, installation and commissioning are considered not part of the project, and the end of the project is defined as 'Silicon Tracker Ready for Installation'. This prudently decouples the Run2b projects from Tevatron operations, and provides for completion of the projects independent of their installation.

2.1.3.1.2. Both teams presented advanced conceptual plans for installation and commissioning of the tracker upgrades.

2.1.3.1.3. An adequate number of Level 2 (L2) and Level 3 (L3) milestones exist to track the project efficiently.

2.1.3.1.4. Subproject specific critical path existed for the D0's (Trigger, DAQ and Online schedules) and CDF's (Trigger and Data Acquisition schedules).

2.1.3.1.5. Neither project showed an overall project critical path that includes both silicon and non-silicon subprojects.

2.1.3.2. Comments

2.1.3.2.1. Both the CDF and D0 upgrade projects are relatively short projects with aggressive schedules in order to maximize the opportunity for physics prior to the turn-on of the LHC.

2.1.3.2.2. For the CDF and D0 upgrade projects to be considered successful, the baseline schedule must be achieved. A superior technical detector, which does not provide an adequate window for research, is not a successful project. With this in mind, both management teams are urged to maintain progress against their baseline schedule as their highest priority.

2.1.3.2.3. Both projects are encouraged to status their projects with 'work performed' in the R&D section to provide feedback on their current performance against their planned work.

2.1.3.2.4. Both projects have set aside considerable contingency funds to provide the necessary resources to maintain progress against the schedule. However, while baseline peoplepower was allotted for, it was not evident that an appropriate staffing plan is available should additional people resources above the baseline estimates become necessary.

2.1.3.2.5. Attempts to introduce descoping or upscoping scenarios in order to provide cost and schedule flexibility are apparently not viable for either project without impacting the scientific mission of the projects.

2.1.3.2.6. Schedule contingency for both projects is contained in the Level 1 and 2 milestones, which it appear there is adequate schedule contingency to complete the projects by the CD-4 date.

2.1.3.2.7. The milestones appeared to be adequate for D0's non-silicon project, but CDF non-silicon projects need additional ones added.

2.1.3.2.8. While work needs to be done to develop the non-silicon schedules more completely, many of these activities involve work that is outside of the physical boundary of the detectors and are mainly independent of other tasks. Access to the detector is needed to the CTT (D0) and for the TDCs and calorimeter work in CDF. The non-silicon activities appear to have minimal schedule risk to impact the overall projects critical path.

2.1.3.2.9. Meeting the Directors Milestones will not be easy. However, we believe they can be met if the following conditions are met:

- 2.1.3.2.9.1. adequate project management and administration staff and support exists,
- 2.1.3.2.9.2. level 3 managers are put in place and level 2 and level 3 managers dedicate adequate time (frequently full time) to their tasks,
- 2.1.3.2.9.3. adequate engineering and technical support staff (including contingency labor) to carry out the work is provided,
- 2.1.3.2.9.4. laboratory management provides a high level of support and puts a high priority on these projects, and
- 2.1.3.2.9.5. Project Managers effectively manage the overall effort.

2.1.3.2.10. The milestones appeared to be adequate for D0's non-silicon project, but CDF non-silicon projects need additional ones added.

2.1.3.2.11. While work needs to be done on the non-silicon schedules, many of these activities are outside the detector and are mainly independent of other activities. Access to the detector is needed to the CTT (D0) and for the TDCS and calorimeter work in CDF. The non-silicon activities appear to have minimal schedule risk to impact the overall projects critical path.

2.1.3.3. Recommendations

2.1.3.3.1. Ensure that the staffing plan supports the full usage of the contingency funds without slipping schedule.

2.1.3.3.2. Examine alternative paths to compress the schedule (and add flexibility) by using additional staff and/or shifts either at Fermilab or other critical parts providers.

2.1.3.3.3. Both projects should use a MS Project master project schedule as one of the tools for accessing and managing the overall project, which includes an integrated project critical path.

2.1.3.3.4. All schedules need to be progressed to show what work has been accomplished for the period prior to the DOE review. Some schedules have been progressed, but not through the current period. Others schedules have not been progressed at all.

2.1.3.3.5. The non-silicon schedules are to have a scheduled end date no later than the Silicon's aggressive schedule end date.

2.2. DZero Specific Cost and Schedule Items

2.2.1. Overall Assessment

2.2.1.1. Findings

2.2.1.1.1. The D0 Run IIb management team presented an organization chart with a staffed project office and subsystem management through Level 3.

2.2.1.1.2. The D0 Run IIb uses a single-source resource loaded MS Project file for all project information. The D0 project file contains ~1780 lines, and provides a fully-integrated work plan for the D0 silicon effort. This plan has been developed by the cognizant L2/L3 managers and includes all relevant project information, including an estimate of the contingency needs.

2.2.1.1.3. Burdening, (indirect costs and escalation factors) are added external to the project file manually. In the future this will be done using COBRA. COBRA will be the primary cost tracking tool and will be utilized to calculate earned value.

2.2.1.1.4. A risk assessment of the D0 upgrade was performed which found that the SVX4 chip and L0 analog flex cables were the areas of highest risk. Hybrids were also found to carry significant uncertainty for the project.

2.2.1.2. Comments

2.2.1.2.1. As pointed out earlier in this report, there has been a significant amount of progress, both technically and organizationally, in the D0 project. It was clear to the committee that the D0 management team has a good understanding of the challenges they have before them. This has allowed the project team to assign contingency with a higher degree of confidence than would otherwise be possible.

2.2.1.2.2. The D0 project is a relatively short project with a sharp increase in funding in FY03 and FY04, followed by project completion in late FY05. As there is no explicit slack in the schedule, performance against the schedule must be monitored closely.

2.2.1.2.3. No performance versus schedule data was presented for the current effort on the D0 upgrade project. This information would be very helpful to both the D0 management and the baseline review committee, and this committee encourages every effort be made to understand the current progress against the schedule.

2.2.1.2.4. The rise in D0 funding is matched by a corresponding rise in the resources needed to accomplish work. This will require careful coordination by the L2/L3 managers to ensure that progress is made against the baseline plan.

2.2.1.3. Recommendations

2.2.1.3.1. Measure, as soon as possible, your current progress against the current schedule.

2.2.2. Total Project Cost Estimates

2.2.2.1. Findings

2.2.2.1.1. D0 presented a silicon cost estimate of 12.0 M$ with a contingency of 6.9 M$ (58%). The cost is split in 8.1 M$ for M&S (with a 60% contingency of 4.8 M$) and 3.9 M$ in labor (with a 54% contingency of 2.1 M$). Labor accounts for 33% of the total project cost.

2.2.2.1.2. The cost is almost totally US-based. The cost is presented in a fully resource loaded schedule with a WBS dictionary and extensive Basis Of Estimate (BOE) documentation that we could trace down to the lowest WBS level. Most of the money is spent in FY03 and FY04.

2.2.2.1.3. The major cost item for D0 M&S are the sensors (2.4 M$) and the hybrids (4.2 M$). Labor-wise, D0 averages approximately 70 FTEs, of which approximately 50 FTEs are SiDet personnel.

2.2.2.1.4. In several cases the M&S cost estimate is based on vendor quotes and existing technical specifications. High risk is associated with alternative sensor vendors (ELMA) that are not properly reflected in the contingency associated with the task. Labor appears to be estimated based on stop-watch studies and verbal communication with people involved in previous silicon construction.

2.2.2.1.5. The EDIA=”non-touch labor”/(M&S+”touch labor”) ratio in D0 is 23% including only project-paid technical labor, and 81% including physicists if costed at 49$/h.

2.2.2.1.6. The following non-silicon Bases of Estimates (BOE) were made available for review. The committee did not have time to review all aspects of the various projects. A "yes" in the "Reviewed" column indicates that a fairly detailed "drill down" exercise was performed. For the other projects, committee members just read the provided material.

WBS#	Name	Est. Cost	Reviewed
1.2	Trigger systems	4.5M	

1.2.1	L1 calorimeter trigger	1.333M	Yes
1.2.2	Calorimeter/Track match	.257M	Yes
1.2.3	L1 central track trigger	1.181M*	Yes
1.2.4	L2 beta system	.064M	
1.2.5	L2 silicon track trigger	.329M	
1.3	DAQ Online	1.4M	
1.3.1	Level 3 systems (filter farm)		
1.3.2	Network & Host systems		Yes Briefly
1.3.2.4	Storage systems		
1.3.2.6	DAQ hosts		
1.3.2.7	Oracle database systems		
1.3.2.8	File servers		
1.3.3	Control systems		
1.3.4	DAQ/online		

*(No FNAL labor or G&A)

2.2.2.2. Comments

2.2.2.2.1. In general the management team appears relatively strong on the back-up of M&S cost estimates. Not much documentation and support was made available to judge the readiness of running a 12M$ factory over 2 years although the committee got the feeling that all the proper words were mentioned (Incoming Inspection, Multiple Vendors, Parts Flow, Travelers, Discrepancy Reports,…).

2.2.2.2.2. This is the 2nd silicon detector built by D0. Manpower estimates based on historical charge-back would go a long way to really convince a cost review committee that the manpower estimate is based on solid ground.

2.2.2.2.3. The labor cost estimating method uses “hours” as the smallest estimate unit. The committee was told that the estimate was determined by a “stop-watch” method. This estimating method does not naturally include daily inefficiencies and need to be escalated for manpower inefficiency factors by approximately 15%. The committee, however, doesn’t believe the estimate was actually made by a “stop-watch” method. Rather it was probably done with the usual assumption of daily productivity, since the overall labor cost estimate appears to be in a good relationship with the total project cost. The EDIA ratio is comparable to experience from previous projects.

2.2.2.2.4. Cost for SiDet personnel training is not covered in the project. The assumption is that trained personnel are provided and their training is paid for some other way.

2.2.2.2.5. It appears to the Committee review that an additional cost of approximately 150k$ on the base estimate is needed to cover for the transition from 132 ns to 396 ns bunch.

2.2.2.3. Recommendations

2.2.2.3.1. Prepare summary WBS at Levels 3, 4, and 5 to help future reviews.

2.2.2.3.2. Update the cost estimate to baseline for 396 ns bunch crossing.

2.2.2.3.3. Moderately beef-up the Basis Of Estimate documentation. Most of the low-level documentation is available, but needs to be made “reviewer-friendly”. Provide documentation and insure all the numbers roll-up from the lowest BOE through the WBS.

2.2.2.3.4. Provide documentation for labor estimates using a reliability factor for the source of estimate. Obtain from the PPD Budget Office or the 15th floor Personnel Office the actual SiDet cost for the Run IIa silicon detector construction and perform a “sanity check” on the overall labor estimate.

2.2.2.3.5. The mixing of what was called "operations expenses" into the Trigger and DAQ project schedule was confusing. It would be better to pull this out into a clearly off-project activity, such as "pre-operations" or leave it in.

2.2.2.3.6. With some assistance there was success in following D0's non-silicon projects BOE but there is still room for improvement in how it is organized.

2.2.3. Schedule

2.2.3.1. Findings

2.2.3.1.1. The D0 management team has developed a schedule that delivers the Run IIb detector on 22Jul05. No explicit slack has been added to the schedule.

2.2.3.1.2. Three tiers of milestones, with the appropriate levels of hierarchy, have been developed to monitor the progress against the schedule.

2.2.3.1.3. The critical path for the D0 upgrade is the SVX4 chip followed by the hybrids. The critical path then falls to the module and stave assembly at Fermilab’s SiDet facility.

2.2.3.1.4. The schedule duration is adequate although the procurement date of November 2002 for the SVX4 pre-production chip is considered optimistic.

2.2.3.2. Comments

2.2.3.2.1. The D0 upgrade schedule is aggressive. The serious activity has already begun. Is it possible to report how the project is currently doing against the schedule?

2.2.3.2.2. It is clear that parts flow will be an issue for the D0 upgrade project, and the management team is to be commended for beginning a dialogue with the Fermilab procurement department. Project staff should work to advance procurements of key components such as sensors, chips, and hybrids as early as possible to ensure that the SiDet factory can assemble modules and staves at the optimum rate.

2.2.3.2.3. For the schedule to be achieved, advance work on the QA/QC plan and discrepancy issues must be developed now as there is not sufficient time to develop testing scenarios during the module/stave production phase.

2.2.3.2.4. Another key area is a schedule driven procurement plan providing an assured supply of key components to the SiDet facility. There has been good progress toward integrating procurement personnel into the D0 project team.

2.2.3.3. Recommendations

2.2.3.3.1. Ensure that the staffing plan supports the full usage of the contingency funds without slipping schedule.

2.2.3.3.2. Continue to advance procurements as much as technically possible.

2.2.3.3.3. Develop and approve the QA/QC 'Travelers' documentation for module and stave specifications now.

2.2.3.3.4. Examine alternative paths to compress the schedule by using additional manpower and/or shifts either at Fermilab or other critical parts providers.

2.3. CDF Specific Cost and Schedule Items

2.3.1. Overall Assessment

2.3.1.1. Findings

2.3.1.1.1. The CDF Run IIb management team presented an organization chart with a staffed project office and subsystem management team through L2.

2.3.1.1.2. The CDF Run IIb project uses a single-source resource MS Project file for all project information. This plan has been developed by the cognizant L2 managers and includes all relevant project information, including an estimate of the contingency needs.

2.3.1.1.3. Burdening, (indirect costs and escalation factors) are added external to the project file manually. In the future this will be done using COBRA. COBRA will be the primary cost tracking tool and will be utilized to determine earned value.

2.3.1.1.4. A risk assessment of the CDF upgrade was performed which found that the overall schedule, particularly the stave assembly, provided the highest risk. Hybrid assembly was also found to carry significant uncertainty for the CDF project.

2.3.1.2. Comments

2.3.1.2.1. As pointed out earlier in this report, there has been a significant amount of progress, both technically and organizationally, in the CDF project. It was clear to the committee that the CDF management team has a good understanding of the challenges they have before them. This has allowed the project team to assign contingency with a higher degree of confidence than would otherwise be possible.

2.3.1.2.2. Like D0, the CDF project is a relatively short project with a sharp increase in funding in FY03 and FY04, followed by project completion in mid FY05. As there is no explicit slack in the schedule, performance against the schedule must be monitored closely.

2.3.1.2.3. As there is little margin for schedule delay, the committee is concerned about the lack of an organization chart or identified people and roles below L2.

2.3.1.2.4. The committee is also concerned with the lack of adequate QA documentation, procedures and 'Travelers' that are necessary for a project of this scale and scope.

2.3.1.3. Recommendations

2.3.1.3.1. Develop and staff the CDF silicon Run IIb organization through L3 with competent people and defined roles.

2.3.1.3.2. Develop a comprehensive set of QA/QC standards and establish a travelers and procedures to ensure that the module and stave production processes will deliver only quality products.

2.3.2. Total Project Cost Estimates

2.3.2.1. Findings

2.3.2.1.1. CDF presented a silicon cost estimate of 10.1 M$ with a contingency of 4.6 M$ (46%). The cost is split in 7.6 M$ for M&S (with a 46% contingency of 3.5 M$) and 2.5 M$ in labor (with a 45% contingency of 1.1 M$). Labor accounts for 25% of the total project cost.

2.3.2.1.2. No Total US cost was presented. The cost is presented in a fully resource loaded schedule with a WBS dictionary and rather limited BOE documentation. Most of the money is spent in FY03 and FY04.

2.3.2.1.3. The major cost item for CDF M&S are the sensors (1.6 M$) and the hybrids (1.7 M$). Labor-wise, CDF averages approximately 40 FTEs, of which approximately 25 FTEs are SiDet personnel.

2.3.2.1.4. In several cases the M&S cost estimate is based on vendor quotes and already available technical specifications (most notable example the HPK sensors, although the project is still open to $-

Yen fluctuations). Labor is estimated based on verbal communication with people involved in previous silicon construction.

2.3.2.1.5. The EDIA=”non-touch labor”/(M&S+”touch labor”) ratio in CDF is 14% including only project-paid technical labor, and 45% including physicists if costed at 49$/h.

2.3.2.1.6. The following non-silicon Bases of Estimates (BOE) were made available for review. The committee did not have time to review all aspects of the various projects. A "yes" in the "Reviewed" column indicates that a fairly detailed "drill down" exercise was performed. For the other projects, committee members just read the provided material.

WBS#	Name	Est. Cost	Reviewed
1.2	Calorimeter	0.96M	
1.2.1	Preshower/Crack	0.71M	
1.2.2	EM timing	0.25M	
1.3	DAQ/trigger	4.3M	
1.3.1	TDC replacement	1.4M	Yes
1.3.2	Level 2 Decision Crate	0.23M	
1.3.3	XFTII project	1.6M	Yes
1.3.4	Event Builder Upgrade	0.4M	
1.3.5	Computer for Level 3 PC Farm DAQ	0.4M	
1.3.6	SVT upgrade	0.29M	

2.3.2.2. Comments

2.3.2.2.1. In general the management team appears relatively strong on the back-up of M&S cost estimates. Much less documentation and support is made available to judge the readiness of running a 10M$ factory over 2 years.

2.3.2.2.2. This is the 3rd silicon detector built for CDF. Manpower estimates based on historical charge-back would go a long way in convincing a cost review committee that the manpower estimate is based on solid ground.

2.3.2.2.3. The labor cost estimating method uses “work day” as the smallest estimate unit. This estimating method does naturally include daily inefficiencies and need not be escalated for manpower inefficiency factors. On the other hand, the overall labor cost estimate looks on the low side. The EDIA ratio is low when compared to other projects. Cost for SiDet personnel training is not covered in the project. The assumption is that trained personnel are provided and their training is paid for some other way.

2.3.2.2.4. It appears to the Committee review that no cost increase is needed to cover for the 132 ns vs 396 ns bunch crossing difference for the Silicon detector.

2.3.2.2.5. The contingency calculations for the non-silicon projects need a lot of work. There are large contingencies on many items that are claimed to be very similar to what was done for Run IIa.

2.3.2.3. Recommendations

2.3.2.3.1. Prepare summary WBS at Levels 3, 4, and 5 to help future reviews.

2.3.2.3.2. Beef-up the Basis Of Estimate. Much low-level documentation is missing and the WBS dictionary note field is the only input for the estimate. Provide precise documentation showing the Basis Of Estimate as it applies to the CDF project only.

2.3.2.3.3. Provide documentation for labor estimates using a reliability factor for the source of estimate. Obtain from the PPD Budget Office or the 15th floor Personnel Office the actual SiDet cost for the Run I and Run IIa silicon detector construction and perform a "sanity check" on the overall labor estimate.

2.3.2.3.4. Understand and justify (if possible) or increase (if necessary) the EDIA ratio.

2.3.2.3.5. Increase the labor effort for the silicon construction in the SiDet factory.

2.3.2.3.6. Address the procurement lag for major items in an appropriate manner with the FNAL Procurement office for a speedy procurement schedule.

2.3.2.3.7. M&S contingency for the sensor appears low. Due to a complicated Japanese-US collaborative scheme, the project is still open to cost increases due to currency fluctuations. Estimate exposure and reevaluate contingency.

2.3.2.3.8. Improve the Basis of Estimate documentation. It was very hard to follow the Basis of Estimate (BOE) for the non-silicon projects given the way the WBS dictionary and the Cost Books were organized. This needs to be fixed so one can go from the WBS in the schedule to the WBS Dictionary/BOE and then to the Cost Book and backup documentation with little to no assistance.

2.3.2.3.9. Improve the WBS Dictionary descriptions. Non-silicon WBS Dictionary descriptions are weak in content and should be revised. It is not always clear on what the scope of work is.

2.3.2.3.10. Improve the contingency calculations for the non-silicon projects. There are large contingencies on many items that are claimed to be very similar to what was done for Run IIa.

2.3.2.3.11. Review the contingency on the calorimeter upgrade, which appears to be too small.

2.3.2.3.12. Provide an explanation in the WBS Dictionary/Cost Book Notes whenever a contingency is assigned that varies from the project's standard methodology.

2.3.3. Schedule

2.3.3.1. Findings

2.3.3.1.1. The CDF schedule delivers a Run IIb detector by 21Apr05. There is no slack in the baseline schedule and the critical path was determined to be driven by the SVX4 chip followed by the flow of completed hybrids to the SiDet assembly factory.

2.3.3.1.2. A set of milestones is in place that tracks progress across the project and is consistent with the project's completion in Apr05.

2.3.3.1.3. The CDF management team presented progress versus planning for its prototype parts and modules which indicated they are currently approximately on schedule for having the first prototype stave completed by 15Oct02.

2.3.3.2. Comments

2.3.3.2.1. The CDF Run IIb management team has presented an aggressive schedule to provide for the maximum period for physics. To maintain progress against the schedule, the committee finds the following areas need further attention:

2.3.3.2.2. Fully staffed organization and well-defined roles through L3.

2.3.3.2.3. A well established SiDet process with QA/QC procedures and personnel in place.

2.3.3.2.4. A set of contingency plans to add people or shift work to other groups to maintain schedule.

2.3.3.2.5. Another key area is a schedule driven procurement plan providing an assured supply of key components to the SiDet facility. There has been good progress toward integrating procurement personnel into the CDF project team.

2.3.3.2.6. The committee was impressed with the CDF team's progress against the current schedule leading up to the first stave prototype. Keep up the good work!

2.3.3.2.7. The CDF Run IIb schedule is dependent upon the LBL group for a given delivery rate of hybrids. Hybrids are the critical path for module/stave assembly and a key component for the SiDet assembly factory. Every effort should be made to mitigate this risk to the schedule, including setting up an identical and parallel effort at another institution to provide for faster hybrid delivery rates.

2.3.3.2.8. The CDF project L2 milestones contain schedule slack with respect to the end of the related tasks. While prudent to ensure that the milestones will be met, missing a L2 milestone should serve as a serious warning that the project is in danger of slipping the project completion date. Furthermore, milestones set as late as possible may not provide an opportunity to develop work-around strategies, and the CDF management team is encouraged to track and report to upper management its performance against L3 milestones.

2.3.3.3. Recommendations

2.3.3.3.1. Ensure that the staffing plan supports the full usage of the contingency funds without slipping schedule.
2.3.3.3.2. Examine alternative paths to compress the schedule by using additional manpower and/or shifts either at Fermilab or other critical parts providers.
2.3.3.3.3. The number of milestones contained in the Trigger/DAQ schedule appears to be weak. Additional milestones need to be added to better assess progress.
2.3.3.3.4. The calorimeter schedule does not have a critical path. Additional task relationships (predecessor/successor) are missing and need to be added before a critical path will appear.
2.3.3.3.5. In general the non-silicon schedule files have a lot of scheduling mechanics work required prior to the DOE review. This includes such items as predecessors, successors and completing fields required for uploading information into Cobra to establish the baseline budget.

2.4. Management Section Common to Both Detectors

2.4.1. Introduction

The findings, comments, and recommendations in this section are based on a less thorough review than had been planned when the review agenda was prepared. This is because the direction of the questions that arose to be addressed in the "technical breakout session," contained many aspects of a "cost/schedule" nature. Thus, it was determined by the Review Committee Chairman that having a separate "Balance of Committee" breakout session to discuss management and DOE documentation was not practical since the two Cost/Schedule Review SubCommittees would then miss the cost/schedule aspects of the "technical" breakout session.

Nonetheless, some findings, comments, and recommendations can be made.

2.4.1.1. Findings

2.4.1.1.1. D0 has an organization with managers named to Level 3 of the Work Breakdown Structure (WBS), while CDF has managers named only to Level 2 of the WBS.

2.4.1.1.2. The Silicon subprojects for each project are by far the largest cost component. They also define the critical path for each project. The operations at SiDet will need to run in a smooth "factory-like" manner in order to meet the planned project schedules. This especially holds true since a third large effort (and a fourth smaller effort will be underway at SiDet coincidentally with these projects. A study titled "A Review of the Manpower Requirements at the Silicon Detector Facility for the Run IIb and CMS," notes there will be a need to increase staffing at SiDet.

2.4.1.1.3. The SVX4 chips are a crucial item for both detectors.

2.4.1.1.4. Project and Procurement staff have been working together and discussing preliminary plans for procurement support to the project. Preliminary procurement/acquisition plans exist.

2.4.1.1.5. The Silicon Subproject Teams said working meetings or reviews are held prior to placing major orders.

2.4.1.1.6. The two silicon projects together created a comparison document including a cost and manpower comparison.

2.4.1.1.7. An Acquisition Execution Plan draft that is well along has been prepared by a group led by the DOE Project Manager and comprised of DOE Procurement staff and Fermilab project and procurement staff.

2.4.1.1.8. A draft of the Project Execution Plan has been prepared by the DOE Project Manager.

2.4.1.1.9. Rough drafts of the Project Management Plans for each project have been prepared by the CDF and D0 Project Managers.

2.4.1.1.10. Fermilab management has established a 396 ns bunch spacing for collider operations as the technical baseline. As this technical parameter has only recently been defined, both projects still need to make minor changes to their cost, schedule and resource planning to be consistent with the 396 ns option.

2.4.1.1.11. Both projects presented staffing profiles for their baseline planning (excluding contingency).

2.4.1.1.12. The FNAL signature approval sequence is cumbersome, and may pose a schedule risk, particularly for large procurements.

2.4.1.1.13. Both CDF and D0 management teams are putting in place an earned value system utilizing MS Project 2000 and COBRA.

2.4.1.1.14. QA/QC planning for both projects is in its infancy.

2.4.1.1.15. Approximately 10% of all MOU's have been currently signed for both projects.

2.4.1.2. Comments

2.4.1.2.1. As noted in other sections of this report, in several areas in the cost/schedule arena the D0 documentation and "command" of various aspects of the project seemed much better than that of

CDF. This is perhaps largely due to the deeper level of current staffing on the D0 project than on the CDF project. Current staff on both projects seems quite capable and highly dedicated, so the above comment is not a criticism of current CDF staff.

2.4.1.2.2. A great deal of planning will be required to make the SiDet operations run as efficiently and smoothly as required. This will include the following: incoming inspections, multiple vendors, parts flow, QA/QC plans/programs, travelers, discrepancy reports, staffing plans (including contingencies, and machine usage (including maintenance and repairs).

2.4.1.2.3. Because of the crucial nature of the SVX4 chips, it is suggested that an MOU be developed with LBL on this topic. Furthermore, since timely completion of the Run IIb Detectors is critical to physics at FNAL in the second half of the decade, specific discussions between the Fermilab and LBL Directors on this topic might be appropriate to assure a high priority is given to this effort by LBL management.

2.4.1.2.4. Procurement must be a key part of the project and a key part of the project team.

2.4.1.2.5. A Production Readiness Review procedure is in use for the LHC detector projects.

2.4.1.2.6. The cost comparison for the silicon projects shows a significant difference in labor hours for the projects.

2.4.1.2.7. The Acquisition Execution Plan has been reviewed and commented upon by DOE headquarters Program Office and Office of Science, Division of Construction Management Support. Their comments have been incorporated into subsequent drafts. This is good progress up the program chain of DOE Management.

2.4.1.2.8. The Acquisition Execution Plan has also been reviewed and commented upon by the DOE Office of Engineering and Construction Management. There have been two cycles of such review. The OECM comments seem to be less appropriate for this kind of project which is performed by a single purpose laboratory and is of a highly specialized and technical nature than they might be for another kind of "acquisition".

2.4.1.2.9. The rough draft Project Management Plans do not yet incorporate the cost and schedule baselines presented at this review. Neither do the reflect the sets of schedule milestones and schedule change control thresholds presented in the review.

2.4.1.2.10. While preliminary plans for acquisition show a depth of possible sources, the schedule of placing the procurement orders is optimistic. Given the number of places the requisition needs to stop for approval it appears likely that due to people's absences or inattention, planned procurement times may be delayed. This issue can be mitigated by pre-approval of fiscal year work packages that can contain a number of procurements planned for that specific year. In this context, those procurements would be approved and requisitions need not stop at every desk currently required. This process worked well in other DOE collaborative projects such as SNS and PEPII. Within Fermilab itself, the Main Injector Project established a ‘blue dot’ requisition system to streamline the procurement process. A similar type of system may help to expedite procurements and save schedule on the CDF and D0 upgrade projects.

2.4.1.2.11. Staffing profiles are based on what appear to be informal promises from Particle Physics Division management. The number of staff required is pegged at the net amount of the cost estimate, excluding contingency. Since the contingency is on the order of 50%, the perturbation to the staffing plan may be significant.

2.4.1.2.12. Due to multiple collaborating organizations in these projects, the earned value system may be difficult to implement. Various accounting departments have different lag times for reporting actuals. As an example PPD at Fermilab reports actuals one month later than the other Lab Divisions/Sections. The projects need to develop, with agreement by all participating accounting departments, an accrual method of accounting where predicted costs are accrued monthly.

2.4.1.2.13. Before baselining, the technical baseline and cost and schedule estimates must be commensurate. Since the baseline review is imminent, the technical baseline should be frozen ASAP with its cost and schedule estimates well defined.

2.4.1.2.14. QA/QC documentation for most silicon tracker tasks and measurements were not available, with QC planning currently utilizing physicists for most tasks. Due to the sophistication of hardware and training required, a contribution from an experienced QA/QC professional can be beneficial. Also, both management teams should be proactive in anticipating the QA/QC needs of parts production early in the process and not wait for parts arrival.

2.4.1.2.15. Procedural documentation was not available at the time of the review. Since multiple parties may handle delicate items (Chips, Hybrids, Sensors) availability of procedures at the onset of the project is necessary to eliminate the possibility of damage due to mishandling.

2.4.1.2.16. Both project teams continue to finalize and execute more MOU’s over the next few weeks, which is an area that needs to make progress prior to the baseline review.

2.4.1.3. Recommendations

2.4.1.3.1. CDF should organize and staff the lower levels of the project as soon as possible. This should help in completing a significant amount of work involved in preparations for the Lehman Review. It will also demonstrate the commitment of the collaboration to the project.

2.4.1.3.2. D0 should continue to augment and grow the staff for their project and incorporate the new personnel into the team. These projects are under a much higher pressure to finish by a "date certain" than high energy physics have ever been before. In order to succeed here the project team must be assembled and made into a well-oiled machine in a timely manner.

2.4.1.3.3. A Silicon Production and Staffing plan should be prepared by each project. A Staffing Management Plan addressing how the Projects and Lab will take actions and when human resources will be brought onto and taken off of the project as required to meet the projects' time constraints. These staffing plans should consider alternative sources of staff, outside of Fermilab, such as contract or university labor, to accommodate peak staffing periods. These plans should be reviewed and concurred in by the Head of the Particle Physics Division and the Associate Director for Research.

2.4.1.3.4. Project and laboratory management should focus a high level of attention to the SVX4 chips.

2.4.1.3.5. The project organization charts need to show the relationship with procurement. Also, a description of what the relationship is should be contained in the PMP.

2.4.1.3.6. Pre-production and Production Readiness Reviews need to be established and scheduled for transitions between the phases of prototype to pre-production and pre-production to production. These are formal reviews to verify the requirements/specifications have been meet and a quality product has been produced. The review will validate that the manufacture of the product is capable of producing a quality product, in the quantity required, at the approved cost and can deliver per the schedule.

2.4.1.3.7. The labor differences for silicon must be understood and explained before the Lehman Review.

2.4.1.3.8. The Fermilab Project Manager's should support the DOE Project Manager in gaining approval of the Acquisition Execution Plan.

2.4.1.3.9. The Fermilab Project Managers should complete of the Project Management Plans prior to the Lehman Review.

2.4.1.3.10. Neither project has internalized that additional administrative support will be required to manage the Run IIb projects in today's environment. The limited timeframe to complete both projects requires a properly staffed and equipped project office to increase the probability of success. It is felt that additional people and administrative equipment will be required and that the administrative budget presented during the review should be doubled.

2.4.1.3.11. Prepare a limited number of work packages on a yearly basis that gives Fermilab management the opportunity to examine and approve the planned project work scope for the year, including all procurements.

2.4.1.3.12. Labor effort on both projects needs to be costed in the month that the hours were worked. This is necessary to insure accuracy in the Earned Value Reporting System. This can be accomplished by establishing an accounting accrual methodology to account for the lag in actual labor cost reporting or by submitting the labor effort report for the same month being closed.

2.4.1.3.13. When production/assembly labor is provided by collaborating physicists, document the staffing through signed MOUs.

2.4.1.3.14. Bring cost and schedule baselines in agreement with the 396 ns bunch spacing design.

Appendices

A. Charge to the Review Committee

Charge for the Director's Baseline Review Committee for the Run IIb Detector Upgrades
August 12-15, 2002 (Rev1)

The CDF and D0 collaborations are preparing to start upgrade projects that will make it possible for the experiments to continue operating at higher and higher luminosities through 2008. The systems needing the most attention for higher-luminosity running are the silicon detectors and the data-acquisition/trigger system. The collaborations have submitted Technical Design Reports (TDRs) for these and other required upgrades. The current schedule calls for installation of the new silicon and other detector components in 2005 or early 2006. For the success of the Tevatron Run II program, it is imperative that both the D0 and CDF upgrades be accomplished on this time scale.

This Director's Baseline Review Committee (BRC) has the primary goal of helping the upgrade projects in their preparation to successfully complete a DOE Baseline Review. In this regard, the BRC should:

- Examine the scope of the proposed upgrades. Determine whether 1) the scope is appropriate for optimizing the research reach of the collider detectors, within the guidelines set forth by the Fermilab Directorate, in this time period and 2) the scope is well defined and understood by key participants. Assess the plans for carrying out the design, prototyping, fabrication, assembly and testing of the proposed upgrades.
- Assess the Total Project Cost estimate for the upgrades. Review and assess the detailed "basis of estimate" for the upgrades (both for the R&D components and the "on-project" components). Understand the risks involved in carrying out the projects and assess the cost contingencies that are being proposed.
- Assess the realism of the schedule and consistency of assumed funding profiles. Is there a detailed schedule, including a critical path, for completing the project? Are milestones appropriate in number and type identified so that both the project teams, Fermilab management, and DOE can effectively track and manage progress? Based on past experience, can the proposed schedules be met? Are appropriate schedule contingencies provided? Is there a "resource loaded schedule" and plan for providing the needed resources (M&S and technical support staff and physicists)? Have techniques such as forward funding by collaborators and phased funding of large contracts been appropriately incorporated into the planning? Does the anticipated funding profile support the resource requirements?
- Comment on the proposed management arrangements for the upgrades. Assess the probable effectiveness of the proposed management arrangements; the internal project structure, coordination between experiments, coupling to the Particle Physics Division and the Directorate and coordination with the Beams Division. Review and assess the formal required DOE documentation: Acquisition Plan, Project Management Plan, Project Execution Plan (as it sets requirements on the PMP), in addition to Scope, Cost,

and Schedule Performance Baseline (which should be "conservatively" derived from the information presented in response to the bullets above) and plans for the use of (and progress toward meeting) cost and schedule reporting tools.

Review findings, assessments, and recommendations should be presented in writing at a closeout with the Collaborations and Fermilab management.

B. Additional Charge Information

Run IIb Goals and Conditions

The goal of Run IIb operation of the Tevatron and the two collider detectors, CDF and D0, is to exploit the increasing luminosity of the Tevatron to search for new phenomena, including, but not limited to, the light Higgs boson if it exists.

We anticipate that modest upgrades to the Tevatron Collider complex, will lead to the accumulation of an integrated luminosity in the region of 15 inverse femtobarns. The details of the evolution of the performance of the Tevatron collider influence the running conditions under which the detectors must be able to operate. Until recently, the specification given to the detectors for planning the Run IIb upgrades was to be able to operate efficiently with an instantaneous luminosity at the start of a store of $5x10^{32}$ cm^{-2} sec^{-1} with a bunch spacing of 132 nsec.

The most recent information on collider operation indicates that operating with a bunch spacing of 396 nsec offers a surer path to higher luminosities. If the peak luminosity available from the collider at 396 nsec is $4x10^{32}$ cm^{-2} sec^{-1}, but luminosity leveling is used to keep the luminosity at $2x10^{32}$ cm^{-2} sec^{-1} because of detector limitations, the achievable integrated luminosity is expected to be the same as if there were no leveling and an initial luminosity of about $3.4x10^{32}$ cm^{-2} sec^{-1}. Since luminosity leveling has not yet been demonstrated, the upgraded detectors should retain the capability of running with 132 nsec bunch spacing. The 396 nsec option is the baseline plan for the collider, however, since it very probably will lead to the most physics on tape.

Two effects determine the rate conditions for the experiments:

- When the instantaneous luminosity is reduced, everything else being equal, the trigger and data rates are reduced.
- When the bunch spacing is increased from 132 nsec to 396 nsec, at fixed luminosity, the number of interactions per bunch crossing increases, and therefore so does the number of fake triggers. The number of interactions per crossing at $2x10^{32}$ cm^{-2} sec^{-1} with 396 nsec is comparable to $5x10^{32}$ cm^{-2} sec^{-1} with 132 nsec.

The Run IIb detectors must be designed to take advantage of the full capability of the high-P_T physics program, which leads to two requirements for running with 396 ns spacing. The first is that the detectors should operate efficiently, with some margin of error, at a luminosity of $2x10^{32}$ cm^{-2} sec^{-1} and a bunch separation of 396 nsec. Since the luminosity would remain at that level for much of a store, it is important that this condition can be met safely, taking into account the uncertainties in estimating occupancies. A contingency of a factor of two seems prudent, for example, in extrapolating present occupancies to expected conditions at $2x10^{32}$ cm^{-2} sec^{-1} for the upgraded detectors.

The second requirement is to ensure that comparable physics reach can be attained even if luminosity leveling is not achieved. This would necessitate at an initial luminosity approaching $4x10^{32}$ cm^{-2} sec^{-1} for the first part of the store, although this condition would ease with the familiar exponential decay. Thus one should design for a luminosity of $4x10^{32}$ cm^{-2} sec^{-1} , but in this case without the need of an additional contingency, since most of the collisions will occur at luminosity well below the initial one.

Within realistic errors of extrapolation and simulation, these two approaches reach the same conclusion. The Run IIb detectors should be designed to be efficient for the most important high-p_T physics processes at luminosities up to approximately $4x10^{32}$ cm^{-2} sec^{-1} at 396 nsec bunch spacing.

C. Committee Membership

Technical Review Subcommittee

Name	Affiliation
Lothar Bauerdick	FNAL
Francesco Forti	INFN/Pisa
Daniel Marlow	Princeton Univ.
Jim Pilcher (Chair)	Univ. of Chicago
Hartmut Sadrozinski	Univ. of California/Santa Cruz
Mats Selen	Univ. of Illinois/Urbana
Hiro Tajima	SLAC

Cost and Schedule Review Subcommittee

Name	Affiliation
Giorgio Apollinari	FNAL
Joel Butler (Chair, Non-Silicon SubComm.)	FNAL
Tony Chargin (Chair, Silicon SubComm.)	ORNL/SNS
Dean Hoffer	FNAL
Daniel Marlow	Princeton Univ.
Jim Pilcher	Univ. of Chicago
Mark Reichanadter	FNAL
Hiro Tajima	SLAC
Ed Temple	FNAL

D. List of Attendees

<u>CDF</u>

Nicola Bacchetta

Doug Benjamin

Brenna Flaugher

Al Goshaw

Joey Huston

Steve Kuhlmann

Nigel Lockyer

Pat Lukens

Christoph Paus

Kevin Pitts

Rob Roser

<u>DZero</u>

Alice Bean

Jerry Blazey

Bill Cooper

Marcel Demarteau

Hal Evans

Bill Freeman

Stu Fuess

Jon Kotcher

Meenakshi Narain

Andrei Nomerotski

Vivian O'Dell

Rich Partridge

Rich Smith

John Womersley

Darien Wood

<u>Observers</u>

John Cooper

Hugh Montgomery

Ken Stanfield

Mike Witherell

<u>DOE</u>

Jim Miller

Jane Monhart

Paul Philp

E. Review Agenda

Detailed Agenda for
Director's Review of CDF and D0 Run IIb Detector Upgrades
August 12-15, 2002
Fermilab Comitium WH 2 East

Monday, August 12 Meet in 1 West

8:00 AM	50m	Committee in Executive Session	
9:00	30m	Fermilab Program Overview & Run IIb Scope	Directorate
9:30	10m	D0 Collaboration Goals and Commitment	Spokesperson
9:40	50m	D0 Detector Upgrade PM Overview	Kotcher
10:30	15m	Break	
10:45	45m	Silicon: Technical Presentation	Demarteau
11:30	45m	Silicon: Cost & Schedule Summary	Bean
12:15	60m	LUNCH	Cmte & CDF/D0
1:15 PM	10m	CDF Collaboration Goals and Commitment	Spokesperson
1:25	50m	CDF Detector Upgrade PM Overview	Lukens
2:15	15m	Break	
2:30	45m	Silicon: Technical Presentation	Bacchetta
3:15	45m	Silicon: Cost & Schedule Summary	Flaugher
4:00	120m	Executive Session	
6:00		Leave for Dinner	

Tuesday, August 13 Meet in 1 West

Morning	min		
8:00	50	D-Zero Trigger	Wood
8:50	20	DAQ	Fuess
9:10	20	D-Zero Installation	Smith
9:30	20	BREAK	
9:50	45	Calorimeter	Kuhlmann
10:35	45	CDF Trigger/DAQ	Pitts
11:20	20	CDF Installation	Roser
11:40	60	WORKING LUNCH (Determine Tech Breakout Topics)	

Afternoon, (Technical SubCommittee and Balance of Committee in Separate Sessions)

Technical SubCommittee – Comitium			Balance of Committee – 1 North		
1:00PM	150m	Selected topics in Tech Breakout and/or 1-on-1 Discussions	1:00PM	120m	Review of Detector DOE Documentation AEP, PMP, (PEP) & Plans for Cost Performance Rptg
			2:50	30m	Details of Cost / Schedule Review
3:30	120m	Full Committee Executive Session			

Wednesday, August 14

(Technical SubCommittee and Balance of Committee in Separate Sessions)

Technical SubCommittee – Comitium		
8:00 AM	60m	Continue Selected topics in Tech Breakout and/or 1-on-1 Discussions as needed
9:00	180m	Draft Report
12:00	60m	Working LUNCH Dry Run Technical Closeout with Full Committee
1:00	60m	Finalize transfer files
2:00	60m	Technical Closeout
3:00	150m	Technical S/C members who must leave may do so. All remaining reviewers continue CDF Cost / Schedule Review

Cost / Schedule Review Breakouts: Silicon & Non-Silicon Subcommittees

8:00 AM	30m	D0 Cost / Schedule Overview 1 – North			
8:30	15m	Procurement Planning			
D0 Silicon SubCommittee – 1 North			D0 Non-Silicon Committee – Snakepit (2WH-NE)		
8:45AM	120m	D0 Silicon Cost Estimate Review	8:45	110m	D0 non - Silicon Cost Estimate Review
10:45	60m	D0 Silicon Schedule Review	10:35	30m	D0 non-Silicon Schedule Review
11:45	60m	Working LUNCH, Technical SubCommittee Closeout Dry Run			
1:00 PM	30m	CDF Cost / Schedule Overview 1 – North			
CDF Silicon SubCommittee – 1 North			CDF Non-Silicon Committee - Snakepit		
1:30	30m	CDF Silicon Cost Estimate Review	1:30PM	30m	CDF non-Silicon Cost Estimate Review
2:00	60m	Technical Closeout			
3:00	90m	Continue CDF Silicon Cost Estimate Review	3:00	80m	Continue CDF non-Silicon Cost Estimate Review
4:30	60m	CDF Silicon Schedule Review	4:20	30m	CDF non-Silicon Schedule Review

5:30	60m	Executive Session

Thursday, August 15

8:00	60	Executive Session
9:00	60	Final 1-on-1 discussions with project personnel as needed
10:00	120	Draft Report
12:00	60	Working LUNCH with Closeout Dry Run
1:00	60m	Finalize transfer files
2:00	45	~2 pm Cost / Schedule / Management Closeout